

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT				1. CONTRACT ID CODE J		PAGE OF PAGES 1 2	
2. AMENDMENT/MODIFICATION NO. 0011		3. EFFECTIVE DATE 18-Jun-2003		4. REQUISITION/PURCHASE REQ. NO.		5. PROJECT NO.(If applicable) 0250570	
6. ISSUED BY USA ENGINEER DISTRICT, SEATTLE ATTN: CENWS-CT P.O. BOX 3755 SEATTLE WA 98124-3755		CODE DACA67		7. ADMINISTERED BY (If other than item 6) See Item 6			
8. NAME AND ADDRESS OF CONTRACTOR (No., Street, County, State and Zip Code)				X		9A. AMENDMENT OF SOLICITATION NO. DACA67-03-R-0210	
				X		9B. DATED (SEE ITEM 11) 22-Apr-2003	
						10A. MOD. OF CONTRACT/ORDER NO.	
						10B. DATED (SEE ITEM 13)	
CODE		FACILITY CODE					
11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS							
<input checked="" type="checkbox"/> The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offer <input type="checkbox"/> is extended, <input checked="" type="checkbox"/> is not extended. Offer must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended by one of the following methods: (a) By completing Items 8 and 15, and returning <u>0</u> copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.							
12. ACCOUNTING AND APPROPRIATION DATA (If required)							
13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.							
A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.							
B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(B).							
C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:							
D. OTHER (Specify type of modification and authority)							
E. IMPORTANT: Contractor <input type="checkbox"/> is not, <input type="checkbox"/> is required to sign this document and return _____ copies to the issuing office.							
14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.) <div style="text-align: center; padding: 20px;">BATTLE SIMULATION CENTER, FORT LEWIS, WA - SEE CONTINUATION</div>							
Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.							
15A. NAME AND TITLE OF SIGNER (Type or print)				16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)			
				TEL: _____ EMAIL: _____			
15B. CONTRACTOR/OFFEROR _____ (Signature of person authorized to sign)		15C. DATE SIGNED		16B. UNITED STATES OF AMERICA BY _____ (Signature of Contracting Officer)		16C. DATE SIGNED 18-Jun-2003	

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

A. This amendment provides for the following revisions to the solicitation:

1. Technical Specification Section 16415, Electrical Work, Interior, is revised to clarify the power conditioners.

B. The revised attached pages supersede pages of the same number and should be inserted in numerical sequence. All changes are generally identified, for your convenience, either by strikeout for deletions, and underlining of text for additions or single dark line in the margin. All portions of the revised or new pages shall apply to this contract whether or not changes have been indicated.

C. The time and date for receipt of proposals remain unchanged at 2:00 p.m., local time, 23 June 2003.

D. Offerors must acknowledge receipt of this amendment by number and date on the Standard Form 1442 BACK (page 00010-2) in Block 19 or by telegram.

Enclosure:
Rev. 16415

SECTION 16415

ELECTRICAL WORK, INTERIOR

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments
ANSI C78.1	(1991; C78.1a; R 1996) Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics
ANSI C78.1350	(1990) Electric Lamps - 400-Watt, 100-Volt, S51 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1351	(1989) Electric Lamps - 250-Watt, 100-Volt S50 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1352	(1990) Electric Lamps - 1000-Watt, 250-Volt, S52 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1355	(1989) Electric Lamps - 150-Watt, 55-Volt S55 High-Pressure Sodium Lamps
ANSI C78.1375	(1996) 400-Watt, M59 Single-Ended Metal-Halide Lamps
ANSI C78.1376	(1996) 1000-Watt, M47 Metal-Halide Lamps
ANSI C78.20	(1995) Electric Lamps - Characteristics of Incandescent Lamps A, G, PS, and Similar Shapes with E26 Medium Screw Bases
ANSI C78.21	(1995) Physical and Electrical Characteristics - Incandescent Lamps - PAR and R Shapes
ANSI C78.2A	(1991) 18 & 26- Watt, Compact Fluorescent Quad Tube Lamps **
ANSI C78.2B	(1992) 9 & 13-Watt, Compact Fluorescent Quad Tube Lamps **
ANSI C82.1	(1997) Specifications for Fluorescent Lamp Ballasts Addenda D & E

ANSI C82.4 (1992) Ballasts for High-Intensity-Discharge
and Low-Pressure Sodium Lamps (Multiple-
Supply Type)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 1 (1995) Hard-Drawn Copper Wire

ASTM B 8 (1999) Concentric-Lay-Stranded Copper
Conductors, Hard, Medium-Hard, or Soft

ASTM D 709 (2000) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.20.1 (1993) Metal-Enclosed Low-Voltage Power
Circuit-Breaker Switchgear

IEEE C57.13 (1993) Instrument Transformers

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage
AC Power Circuits

IEEE Std 242 (1986; R 1991) Recommended Practice for
Protection and Coordination of Industrial and
Commercial Power Systems

IEEE Std 399 (1997) Recommended Practice for Industrial
and Commercial Power Systems Analysis

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity,
Ground Impedance, and Earth Surface
Potentials of a Ground System (Part 1)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1997) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA AB 1 (1993) Molded Case Circuit Breakers and
Molded Case Switches

NEMA FU 1 (1986) Low Voltage Cartridge Fuses

NEMA ICS 1 (1993) Industrial Control and Systems

NEMA ICS 2 (1993) Industrial Controls and Systems
Controllers, Contactors, and Overload Relays
Rated Not More Than 2,000 Volts AC or 750
Volts DC

NEMA ICS 3 (1993) Industrial Control and Systems Factory
Built Assemblies

NEMA ICS 6 (1993) Industrial Control and Systems,
Enclosures

NEMA LE 4	(1987) Recessed Luminaires, Ceiling Compatibility
NEMA MG 1	(1998) Motors and Generators
NEMA MG 10	(1994) Energy Management Guide for Selection and Use of Polyphase Motors
NEMA OS 1	(1996) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA OS 2	(1998) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA PB 1	(1995) Panelboards
NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA ST 20	(1992) Dry-Type Transformers for General Applications
NEMA TC 2	(1998) Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 and EPC-80)
NEMA VE 1	(1996) Metal Cable Tray Systems
NEMA WD 1	(1999) General Requirements for Wiring Devices
NEMA WD 6	(1997) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2000) Life Safety Code
NFPA 70	(2002) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 18	Industrial, Scientific, and Medical Equipment
-----------	-----------------------------------------------

UNDERWRITERS LABORATORIES (UL)

UL 1	(2000) Flexible Metal Conduit
UL 1004	(1994; Rev thru Nov 1999) Electric Motors
UL 1029	(1994; Rev thru Dec 1997) High-Intensity-Discharge Lamp Ballasts
UL 1449	(1996; Rev thru Dec 1999) Transient Voltage Surge Suppressors
UL 1569	(1999; Rev thru Jan 2000) Metal-Clad Cables

UL 1570	(1995; Rev thru Nov 1999) Fluorescent Lighting Fixtures
UL 1571	(1995; Rev thru Nov 1999) Incandescent Lighting Fixtures
UL 1572	(1995; Rev thru Nov 1999) High Intensity Discharge Lighting Fixtures
UL 1660	(2000) Liquid-Tight Flexible Nonmetallic Conduit
UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 198L	(1995; Rev May 1995) D-C Fuses for Industrial Use
UL 360	(1996; Rev thru Oct 1997) Liquid-Tight Flexible Steel Conduit
UL 4	(1996) Armored Cable
UL 486A	(1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486C	(1997; Rev thru Aug 1998) Splicing Wire Connectors
UL 486E	(1994; Rev thru Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 5	(1996) Surface Metal Raceways and Fittings
UL 50	(1995; Rev thru Nov 1999) Enclosures for Electrical Equipment
UL 506	(1994; R Oct 1997) Specialty Transformers
UL 508	(1999) Industrial Control Equipment
UL 510	(1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

UL 512	(1993; Rev thru Mar 1999) Fuseholders
UL 514A	(1996; Rev Dec 1999) Metallic Outlet Boxes
UL 514B	(1997; Rev Oct 1998) Fittings for Cable and Conduit
UL 514C	(1996; Rev thru Dec 1999) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 542	(1999) Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 6	(1997) Rigid Metal Conduit
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(1995; Rev thru Apr 1998) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 67	(1993; Rev thru Oct 1999) Panelboards
UL 674	(1994; Rev thru Oct 1998) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 797	(1993; Rev thru Mar 1997) Electrical Metallic Tubing
UL 817	(1994; Rev thru May 1999) Cord Sets and Power-
UL 83	(1998; Rev thru Sep 1999) Thermoplastic-Insulated Wires and Cables
UL 845	(1995; Rev thru Nov 1999) Motor Control Centers
UL 869A	(1998) Reference Standard for Service Equipment
UL 877	(1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 891	(1994; Rev thru Jan 1995) Dead-Front Switchboards
UL 916	(1998) Energy Management Equipment
UL 924	(1995; Rev thru Oct 97) Emergency Lighting and Power Equipment
UL 935	(1995; Rev thru Oct 1998) Fluorescent-Lamp Ballasts

UL 943	(1993; Rev thru May 1998) Ground-Fault Circuit-Interrupters
UL 98	(1994; Rev thru Jun 1998) Enclosed and Dead- Front Switches
UL Elec Const Dir	(1999) Electrical Construction Equipment Directory

1.2 GENERAL

1.2.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated or shown.

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Lighting fixtures, outlets, and other equipment and materials shall be carefully coordinated with mechanical or structural features prior to installation and positioned according to architectural reflected ceiling plans; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. The Contractor shall coordinate the electrical requirements of the mechanical work and provide all power related circuits, wiring, hardware and structural support, even if not shown on the drawings.

1.2.3 Special Environments

1.2.3.1 Weatherproof Locations

Wiring, Fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

1.2.3.2 Ducts, Plenums and Other Air-Handling Spaces

Wiring and equipment in ducts, plenums and other air-handling spaces shall be installed using materials and methods in conformance with NFPA 70 unless more stringent requirements are indicated in this specification or on the contract drawings.

1.2.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially

duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.2.5 Nameplates

1.2.5.1 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic in accordance with ASTM D 709 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 1/4 inch High Letters	Minimum 1/8 inch High Letters
Panelboards	Control Power Transformers
Starters	Control Devices
Safety Switches	Instrument Transformers
Motor Control Centers	
Transformers	
Equipment Enclosures	
Switchgear	
Switchboards	
Motors	

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

1.2.6 As-Built Drawings

Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as-built drawings to the Contracting Officer.

1.2.7 Recessed Light Fixtures (RLF) Option

The Contractor has the option to substitute inch-pound (I-P) RLF to metric RLF. This option shall be coordinated with Section 09510 ACOUSTICAL CEILINGS.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Interior Electrical Equipment; G.

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation. Detail drawings shall show the rating of items and systems and how the components of an item and system are assembled, function together, and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall show physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded. Detail drawings shall as a minimum include:

- a. Substation.
- b. Dry Type Transformers.
- c. Switchgear.
- d. Power conditioners.
- e. Motors and rotating machinery.
- f. Motor controllers.
- g. Single line electrical diagrams including primary, metering, sensing and relaying, control wiring, and control logic.
- h. Sway bracing for suspended luminaires.

Structural drawings showing the structural or physical features of major equipment items, components, assemblies, and structures, including foundations or other types of supports for equipment and conductors. These drawings shall include accurately scaled or dimensioned outline and arrangement or layout drawings to show the physical size of equipment and components and the relative arrangement and physical connection of related components. Weights

of equipment, components and assemblies shall be provided when required to verify the adequacy of design and proposed construction of foundations or other types of supports. Dynamic forces shall be stated for switching devices when such forces must be considered in the design of support structures. The appropriate detail drawings shall show the provisions for leveling, anchoring, and connecting all items during installation, and shall include any recommendations made by the manufacturer.

Electrical drawings including single-line and three-line diagrams, and schematics or elementary diagrams of each electrical system; internal wiring and field connection diagrams of each electrical device when published by the manufacturer; wiring diagrams of cabinets, panels, units, or separate mountings; interconnection diagrams that show the wiring between separate components of assemblies; field connection diagrams that show the termination of wiring routed between separate items of equipment; internal wiring diagrams of equipment showing wiring as actually provided for this project. Field wiring connections shall be clearly identified.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures, including changes in related portions of the project and the reasons why, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

SD-03 Product Data

Fault Current and Protective Device Coordination Study; G.

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Installation Procedures

Installation procedures for rotating equipment, transformers, switchgear, battery systems, voltage regulators, and grounding resistors. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test devices and equipment.

As-Built Drawings; G.

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings, deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full-sized set of prints marked to reflect all deviations, changes, and modifications. The as-built drawings shall be complete and show the location, size, dimensions, part

identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

Onsite Tests; G.

A detailed description of the Contractor's proposed procedures for on-site tests.

Field Test Plan; G.

A detailed description of the Contractor's proposed procedures for onsite test submitted 20 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports; G.

Six copies of the information described below in 8 1/2 x 11 inch (216 x 280 mm) binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The conditions specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.
- h. Final position of controls and device settings.

SD-07 Certificates

Materials and Equipment; G.

The label or listing of the Underwriters Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to

the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Contracting Officer. Items which are required to be listed and labeled in accordance with Underwriters Laboratories must be affixed with a UL label that states that it is UL listed. No exceptions or waivers will be granted to this requirement. Materials and equipment will be approved based on the manufacturer's published data.

For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with NFPA 70, recommendations of the manufacturer, and as shown.

PART 2 PRODUCTS (INTERIOR ELECTRICAL EQUIPMENT)

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 CABLES AND WIRES

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.1.1 Aluminum Conductors

Aluminum conductors shall not be used.

2.1.2 Insulation

Unless indicated otherwise, or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN, THHN, or THW conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW, THW or TF, conforming to UL 83. For all Type MC Cable and where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.1.3 Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter;
ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger
diameter.

2.1.4 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.1.5 Armored Cable

UL 4; NFPA 70, Type AC cable.

2.1.6 Tray Cable or Power Limited Tray Cable

UL listed; Type TC or PLTC.

2.1.7 Cord Sets and Power-Supply Cords

UL 817.

2.2 CABLE TRAYS

Cable tray shall conform to NEMA VE 1, shall form a wireway system, and shall be of nominal depth and width as shown on the Telecommunications (T-series) Drawings. Cable trays shall be constructed of continuous rigid welded steel wire mesh with a minimum diameter of 0.192 inches (.48 cm) on all mesh sections. Mesh size shall be a maximum of 2 inches by 4 inches (5.08 cm by 10.16 cm). Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than the load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be as shown.

2.2.1 Finish

Electroplated Zinc Galvanizing: Electrodeposited zinc coating shall be applied to an average thickness of .7 mils (18 microns).

2.2.2 Support

Provide support per manufacturer's requirements and seismic requirement for the area.

2.3 TRANSIENT VOLTAGE SURGE PROTECTION (TVSP)

Transient voltage surge protection shall be provided as indicated. Protection shall be in the form of surge suppressors which meet the requirements of IEEE C62.41 and be UL listed and labeled as having been tested in accordance with UL 1449. Surge voltage suppressor ratings shall not exceed those specified under UL 1449 for the associated nominal system voltage. Maximum Allowable Continuous Operating Voltage (MCOV) shall be at least 115 percent of the nominal system voltage. Fuses shall not be used as surge suppression.

2.4 CIRCUIT BREAKERS

2.4.1 MOLDED-CASE CIRCUIT BREAKERS

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489 and UL 877 for circuit breakers and circuit breaker enclosures located in hazardous (classified) locations. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers.

2.4.1.1 Construction

Circuit breakers shall be suitable for mounting and operating in any position. Lug shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.4.1.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.4.1.3 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.4.2 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with

distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be torodial construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

- a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.
- b. Adjustable long-time delay.
- c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- d. Adjustable short-time delay.
- e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- f. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but not greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap will not be permitted.
- g. Adjustable ground-fault delay.
- h. Ground-fault I^2t switch.
- i. Overload, short-time, and ground-fault trip indicators shall be provided.

2.4.3 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.4.4 Ground Fault Circuit Interrupters

UL 943. Breakers equipped with ground fault circuit interrupters shall have ground fault class, interrupting capacity, and voltage and current ratings as indicated.

2.5 CONDUIT AND TUBING

2.5.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797

2.5.2 Flexible Conduit, Steel and Plastic

General-purpose type, UL 1; liquid tight, UL 360, and UL 1660.

2.5.3 Rigid Metal Conduit

UL 6.

2.5.4 Rigid Plastic Conduit

NEMA TC 2, UL 651 and UL 651A.

2.5.5 Surface Metal Electrical Raceways and Fittings

UL 5.

2.6 CONDUIT AND DEVICE BOXES AND FITTINGS

2.6.1 Boxes, Metallic Outlet

NEMA OS 1 and UL 514A.

2.6.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.6.3 Fittings for Conduit and Outlet Boxes

UL 514B.

2.6.4 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.7 CONNECTORS, WIRE PRESSURE

2.7.1 For Use With Copper Conductors

UL 486A.

2.8 ENCLOSURES

NEMA ICS 6 or NEMA 250, unless otherwise specified.

2.8.1 Cabinets and Boxes

Cabinets and boxes with volume greater than 100 cubic inches (0.0164 cubic meters) shall be in accordance with UL 50, hot-dip, zinc-coated, if sheet steel.

2.8.2 Circuit Breaker Enclosures

UL 489.

2.9 LIGHTING FIXTURES, LAMPS, BALLASTS, EMERGENCY EQUIPMENT, CONTROLS AND ACCESSORIES

The following specifications are supported and supplemented by information and details on the drawings. Additional fixtures, if shown, shall conform to this specification. Lamps, lampholders, ballasts, transformers, electronic circuitry and other lighting system components shall be

constructed according to industry standards. Equipment shall be tested and listed by a recognized independent testing laboratory for the expected installation conditions. Equipment shall conform to the standards listed below.

2.9.1 Lamps

Lamps shall be constructed to operate in the specified fixture, and shall function without derating life or output as listed in published data. Lamps shall meet the requirements of the Energy Policy Act of 1992.

- a. Incandescent and tungsten halogen lamps shall be designed for 125 volt operation (except for low voltage lamps), shall be rated for minimum life of 2,000 hours, and shall have color temperature between 2,800 and 3,200 degrees Kelvin. Tungsten halogen lamps shall incorporate quartz capsule construction. Lamps shall comply with ANSI C78.20 and sections 238 and 270 of ANSI C78.21.
- b. Fluorescent lamps shall be green-tipped and shall have color temperature as shown of 3,500 degrees Kelvin. They shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used. Fluorescent lamps, including spares, shall be manufactured by one manufacturer to provide for color and performance consistency. Fluorescent lamps shall comply with ANSI C78.1. Fluorescent tube lamp efficiencies shall meet or exceed the following requirements.

T8, 32 watts	(4' lamp)	2800 lumens
T12,34 watts	(4' lamp)	2800 lumens
T8,59 watts	(8' lamp)	5700 lumens
T12,60 watts	(8' lamp)	5600 lumens
T8/U,31-32 watts	(U-tube)	2600 lumens
T12/U,34 watts	(U-tube)	2700 lumens

(1) Linear fluorescent lamps, unless otherwise indicated, shall be 4 feet (1219 mm) long 32 watt T8, 265 mA, with minimum CRI of 75. Lamps of other lengths or types shall be used only where specified or shown. Lamps shall deliver rated life when operated on rapid start ballasts.

(2) Small compact fluorescent lamps shall be twin, double, or triple tube configuration as shown with bi-pin or four-pin snap-in base and shall have minimum CRI of 85. They shall deliver rated life when operated on ballasts as shown. 9 and 13 watt double tube lamps shall comply with ANSI C78.2B. 18 and 26 watt double tube lamps shall comply with ANSI C78.2A. Minimum starting temperature shall be 32 degrees F (0 degrees C) for twin tube lamps and for double and triple twin tube lamps without internal starter; and 15 degrees F (-9 degrees C) for double and triple twin tube lamps with internal starter.

(3) Long compact fluorescent lamps shall be 18, 27, 39, 40, 50, or 55 watt bi-axial type as shown with four-pin snap-in base; shall have minimum CRI of 85; and shall have a minimum starting

temperature of 50 degrees F (10 degrees C). They shall deliver rated life when operated on rapid start ballasts.

- c. High intensity discharge lamps, including spares, shall be manufactured by one manufacturer in order to provide color and performance consistency. High intensity discharge lamps shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used and shall have wattage, shape and base as shown. High intensity discharge lamps, unless otherwise shown, shall have medium or mogul screw base and minimum starting temperature of -20 degrees F (-29 degrees C). Metal halide lamps, unless otherwise shown, shall have minimum CRI of 65; color temperature of 4,300 degrees Kelvin; shall be -BU configuration if used in base-up position; and shall be -H or high output configuration if used in horizontal position. Lamps shall comply with all applicable ANSI C78.1350, ANSI C78.1351, ANSI C78.1352, ANSI C78.1355, ANSI C78.1375, and ANSI C78.1376.

2.9.2 Ballasts and Transformers

Ballasts or transformers shall be designed to operate the designated lamps within their optimum specifications, without derating the lamps. Lamp and ballast combinations shall be certified as acceptable by the lamp manufacturer.

- a. Low voltage incandescent transformers shall be Class II UL listed 120/12 volt or 120/24 volt step-down transformers as required for the lamps shown. Transformers shall be high power factor type and shall be rated for continuous operation under the specified load. Transformers shall be encased or encased and potted, and mounted integrally within the lighting fixture unless otherwise shown.
- b. Fluorescent ballasts shall comply with ANSI C82.1 and shall be mounted integrally within fluorescent fixture housing unless otherwise shown. Ballasts shall have maximum current crest factor of 1.7; high power factor; Class A sound rating; maximum operating case temperature of 77 degrees F (25 degrees C) above ambient; and shall be rated Class P. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture. A single ballast may be used to serve multiple fixtures if they are continuously mounted, identically controlled and factory manufactured for that installation with an integral wireway.

(1) Compact fluorescent ballasts shall comply with IEEE C62.41 Category A transient voltage variation requirements and shall be mounted integrally within compact fluorescent fixture housing unless otherwise shown. Ballasts shall have minimum ballast factor of 0.95; maximum current crest factor of 1.6; high power factor; maximum operating case temperature of 77 degrees F (25 degrees C) above ambient; shall be rated Class P; and shall have a sound rating of Class A. Ballasts shall meet FCC Class A specifications for EMI/RFI emissions. Ballasts shall operate from nominal line voltage of 120 or 277 volts at 60 Hz and maintain constant light output over a line voltage variation of + 10%. Ballasts shall have an end-of-lamp-life detection and shut-down circuit. Ballasts shall be UL listed and shall contain no PCBs. Ballasts shall

contain potting to secure PC board, provide lead strain relief, and provide a moisture barrier.

(2) Electronic fluorescent ballasts shall comply with 47 CFR 18 for electromagnetic interference. Ballasts shall withstand line transients per IEEE C62.41, Category A. Ballasts shall have total harmonic distortion between 10 and 20%; minimum frequency of 20,000Hz; filament voltage between 2.5 and 4.5 volts; maximum starting inrush current of 20 amperes; and shall comply with the minimum Ballast Efficacy Factors shown in the table below. Minimum starting temperature shall be 50 degrees F (10 degrees C). Ballasts shall carry a manufacturer's full warranty of three years, including a minimum \$10 labor allowance per ballast.

ELECTRONIC FLUORESCENT BALLAST EFFICACY FACTORS

LAMP TYPE	TYPE OF STARTER & LAMP	NOMINAL OPERATIONAL VOLTAGE	NUMBER OF LAMPS	MINIMUM BALLAST EFFICACY FACTOR
32W T8	rapid	120 or 277 V	1	2.54
	start		2	1.44
	linear &		3	0.93
	U-tubes		4	0.73
34W T12	rapid	120 or 277 V	1	2.64
	start		2	1.41
	linear & U-tubes		3	0.93
59W T8	rapid start linear	120 or 277 V	2	0.80
60W T12	rapid start linear	120 or 277 V	2	0.80

(3) Magnetic fluorescent ballasts shall be energy-saving, automatic resetting type, approved for the application by the Certified Ballast Manufacturers and complying with ANSI C82.1 and UL 935. Minimum ballast starting temperature shall be 40 degrees F (4.4 degrees C) for normal service and 0 degrees F (-18 degrees C) where cold temperature service is required. Magnetic fluorescent ballasts shall have a ballast factor not less than shown in the following table:

MAGNETIC FLUORESCENT BALLAST FACTORS*

Design starting temperature above 40 degrees F (4.4 degrees C) with 60 Hz input frequency

LAMP TYPE	NUMBER OF LAMPS	NOMINAL OPERATIONAL INPUT VOLTAGE	TYPE OF STARTER & LAMP	MIN. BALLAST FACTOR
25W F25T8	1	120v	rapid start	.96
	1	277v		.96
	2	120v		.95
	2	277v		.94
32W F32T8	1	120v	rapid start	.96
	1	277v		.95
	2	120v		.85
	2	277v		.96
96W F96T8	1	120 or 277v	instant start	1.10
	2			.85

* For ballasts not specifically designed for use with dimming controls.

(4) Dimming fluorescent ballasts shall be electronic and shall comply with the applicable electronic ballast specifications shown above. Dimming ballasts shall be compatible with the specified dimming control equipment and shall operate the lamps shown in the range from full rated light output to 1 percent of full rated light output. Dimming ballasts shall provide smooth square law dimming such that perceived dimming action is proportionate to the motion of the dimming control. Single or two-lamp dimming ballasts shall be used. Multi-lamp dimming ballasts shall be designed to operate lamps of the same length and current rating.

(5) Dimming compact fluorescent ballasts shall be electronic and shall comply with the applicable compact fluorescent and dimming ballast specifications shown above. Ballasts shall operate the lamps shown in the range from full rated light output to 5 percent of full rated light output. Ballast power factor shall be <90% throughout dimming range. THD shall be <10% at maximum light output and <20% at minimum light output. Ballast shall ignite the lamps at any light output setting selected.

c. High intensity discharge ballasts shall comply with UL 1029 and, if multiple supply types, with ANSI C82.4. Ballasts shall have minimum ballast factor of 0.9; high power factor; Class A sound rating; and maximum operating case temperature of 77 degrees F (25 degrees C) above ambient.

(1) Electronic high intensity discharge ballasts shall be constant wattage autotransformer type; shall have less than 10% ballast loss; shall have total harmonic distortion between 10 and 20%; and shall have a minimum starting temperature of 0 degrees F (-18 degrees C).

- (2) Magnetic high intensity discharge ballasts shall have a minimum starting temperature of -20 degrees F (-29 degrees C).

2.9.3 Fixtures

Fixtures shall be in accordance with the size, shape, appearance, finish, and performance shown. Unless otherwise indicated, lighting fixtures shall be provided with housings, junction boxes, wiring, lampholders, mounting supports, trim, hardware and accessories for a complete and operable installation. Recessed housings shall be minimum 20 gauge cold rolled or galvanized steel as shown. Extruded aluminum fixtures shall have minimum wall thickness of 0.125 inches (3 mm). Plastic lenses shall be 100% virgin acrylic or as shown. Glass lenses shall be tempered. Heat resistant glass shall be borosilicate type. Conoid recessed reflector cones shall be Alzak with clear specular low iridescent finish.

- a. Incandescent fixtures shall comply with UL 1571. Incandescent fixture specular reflector cone trims shall be integral to the cone and shall be finished to match. Painted trim finishes shall be white with minimum reflectance of 88%. Low voltage incandescent fixtures shall have integral step-down transformers.
- b. Fluorescent fixtures shall comply with UL 1570. Recessed ceiling fixtures shall comply with NEMA LE 4. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Marking shall be readily visible to service personnel, but not visible from normal viewing angles. Fluorescent fixture lens frames on recessed and surface mounted troffers shall be one assembly with mitered corners. Parabolic louvers shall have a low iridescent finish and 45 degree cut-off. Louver intersection joints shall be hairline type and shall conceal mounting tabs or other assembly methods. Louvers shall be free from blemishes, lines or defects which distort the visual surface. Integral ballast and wireway compartments shall be easily accessible without the use of special tools. Housings shall be constructed to include grounding necessary to start the lamps. Open fixtures shall be equipped with a sleeve, wire guard, or other positive means to prevent lamps from falling. Medium bi-pin lampholders shall be twist-in type with positive locking position. Long compact fluorescent fixtures and fixtures utilizing U-bend lamps shall have clamps or secondary lampholders to support the free ends of the lamps.
- c. High intensity discharge fixture shall comply with UL 1572. Recessed ceiling fixtures shall comply with NEMA LE 4. Reflectors shall be anodized aluminum. Fixtures for horizontal lamps shall have position oriented lampholders. Lampholders shall be pulse-rated to 5,000 volts. Fixtures indicated as classified or rated for hazardous locations or special service shall be designed and independently tested for the environment in which they are installed. Recessed lens fixtures shall have extruded aluminum lens frames. Ballasts shall be integral to fixtures and shall be accessible without the use of special tools. Remote ballasts shall be encased and potted. Lamps shall be shielded from direct view with a UV absorbing material such as tempered glass, and shall be circuited through a cut-off switch which will shut off the lamp circuit if the lens is not in place.

- d. Exit Signs: Exit signs shall be ENERGY STAR compliant, thereby meeting the following requirements. Input power shall be less than 5 watts per face. Letter size and spacing shall adhere to NFPA 101. Luminance contrast shall be greater than 0.8. Average luminance shall be greater than 15 cd/m² measured at normal (0 degree) and 45 degree viewing angles. Minimum luminance shall be greater than 8.6 cd/m² measured at normal and 45 degree viewing angles. Maximum to minimum luminance shall be less than 20:1 measured at normal and 45 degree viewing angles. The manufacturer warranty for defective parts shall be at least 5 years.

2.9.4 Lampholders, Starters, and Starter Holders

UL 542

2.9.5 Ultrasonic, and Passive Infrared Occupancy Sensors

UL 916

2.9.6 Lighting Inverter

- a. The lighting inverter shall be a single phase uninterruptible power supply (UPS) system with a VA rating of 14,000. The system shall be ETL listed to UL standard 924. Equipment and accessories furnished under the terms of this specification shall be the standard product of a single manufacturer. The connected load shall be powered by the rectifier and inverter and, upon failure of the utility input, the load shall automatically continue to be powered via the system's battery and inverter for a minimum of 1.5 hours. Upon restoration of utility power, the system will automatically walk-in the inverter and recharge the batteries even if the batteries are completely discharged. The UPS Series System shall be capable of powering any combination of fluorescent ballasted lamps, incandescent lamps, electronic and high power factor compact fluorescent ballasts, H.I.D lamps or other approved loads up to the total rating of the system. The system shall automatically protect itself from overloads and short circuits.
- b. Under emergency operations, the output voltage shall be within ± 1 percent of nominal at full load for the specified discharge period; and the frequency shall be 60 Hz ± 0.05 percent. The system shall automatically revert to emergency mode operation should the average utility AC voltage fall below 75 percent of the nominal line voltage. The system shall use no relays or other moving parts in the main inverter or battery charger circuitry. During emergency mode operation, the systems' efficiency shall not be less than 90 percent. The system shall use fans in the cooling of the electronic compartments for forced air ventilation. The AC output to the load shall be isolated from the utility input during inverter emergency operation.
- c. Overall Characteristics: 86 percent throughput efficiency. Operating temperature range 32 to 104 degrees F (0 to 40 degrees C). Internal maintenance by-pass and main load

- disconnect switch. Double conversion with no interruption. Provide backup time of 90 minutes.
- d. The rectifier shall be SCR controlled. The rectifier efficiency shall not be less than 97.7 percent. The rectifier shall have a ripple voltage less than 2 percent rms voltage with inverter fully loaded and battery disconnected. Charge voltage applied to the batteries shall be temperature compensated.
 - e. Electronics: Sine wave output. Completely solid-state Pulse Width Modulation (PWM) inverter. 16-bit micro-processor control. Input power factor correction to maintain power factor at 0.99. Transient response ≤ 5 percent, recovery time 10 mS (100 percent load step). 3:1 crest factor capability. Inverter output distortion ≤ 8 percent THD (at unity power factor, 100 percent non-linear load). Output voltage regulation ± 6 percent of nominal at full load. Frequency within ± 0.05 percent of nominal. Inverter efficiency ≥ 90 percent. Load power factor capability is 0.5 leading to 0.5 lagging. Automatic, battery protecting low voltage disconnect (LVD). Advanced battery diagnostics and management system. Temperature compensated battery charger. 24-hour recharge time. High-frequency, very low ripple current charger. Input and output disconnect switch. Fused battery disconnect switch.
 - f. Under emergency mode conditions, the system shall be powered by maintenance-free, sealed lead calcium batteries. The battery shall operate entirely unattended and require no addition of water for a period of 10 years or longer.
 - g. System metering and controls shall consist of computer interface, RS232 port for direct two-way communication, relay contacts to drive remote alarm monitor, a multilingual alphanumerical display of voltage/frequency/current, load percentage crest factor, and the system shall be self-testing/self-diagnostic that automatically perform a minimum 30-second test and diagnostic routine at least every 30 days and indicates failures and alarms. Status, test and alarm information shall be stored in memory and retrievable from unit display.
 - h. Housing: Free-standing NEMA 1 enclosure. Acid-resistant powder coat finish. Multiple conduit entries.

2.10 LOW-VOLTAGE FUSES AND FUSEHOLDERS

2.10.1 Fuses, Low Voltage Cartridge Type

NEMA FU 1.

2.10.2 Fuses, High-Interrupting-Capacity, Current-Limiting Type

Fuses, Class G, J, L and CC shall be in accordance with UL 198C.

2.10.3 Fuses, Class K, High-Interrupting-Capacity Type

UL 198D.

2.10.4 Fuses, Class H

UL 198B.

2.10.5 Fuses, Class R

UL 198E.

2.10.6 Fuses, Class T

UL 198H.

2.10.7 Fuses, D-C for Industrial Use

UL 198L.

2.10.8 Fuseholders

UL 512.

2.11 INSTRUMENTS, ELECTRICAL INDICATING

ANSI C39.1.

2.12 MOTORS, AC, FRACTIONAL AND INTEGRAL

Motors, ac, fractional and integral horsepower, 500 hp (373.0 kW) and smaller shall conform to NEMA MG 1 and UL 1004 for motors; NEMA MG 10 for energy management selection of polyphase motors; and UL 674 for use of motors in hazardous (classified) locations. In addition to the standards listed above, motors shall be provided with efficiencies as specified in the table "MINIMUM NOMINAL EFFICIENCIES" below.

2.12.1 Rating

The horsepower rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range. In this case, the next larger NEMA standard motor size should be used.

2.12.2 Motor Efficiencies

All permanently wired polyphase motors of 1 hp (746 W) or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 1 hp (746 W) or more with open, drip proof or totally enclosed fan cooled enclosures shall be high efficiency type, unless otherwise indicated. Motor efficiencies indicated in the tables apply to general-purpose, single-speed, polyphase induction motors. Applications which require definite purpose, special purpose, special frame, or special mounted polyphase induction motors are excluded from these efficiency requirements. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

<u>kW</u>	<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
0.746	82.5	85.5	80.0
1.12	86.5	86.5	85.5
1.49	87.5	86.5	86.5
2.24	89.5	89.5	86.5
3.73	89.5	89.5	89.5
5.60	91.7	91.0	89.5
7.46	91.7	91.7	90.2
11.2	92.4	93.0	91.0
14.9	92.4	93.0	92.4
18.7	93.0	93.6	93.0
22.4	93.6	93.6	93.0
29.8	94.1	94.1	93.6
37.3	94.1	94.5	93.6
44.8	95.0	95.0	94.1
56.9	95.0	95.0	94.5
74.6	95.0	95.4	94.5
93.3	95.4	95.4	95.0
112.0	95.8	95.8	95.4
149.0	95.4	95.8	95.4
187.0	95.4	96.2	95.8
224.0	95.4	95.0	95.4
261.0	94.5	95.4	95.0
298.0	94.1	95.8	95.0
336.0	94.5	95.4	95.4
373.0	94.5	94.5	94.5

TOTALLY ENCLOSED FAN-COOLED MOTORS

<u>kW</u>	<u>1200 RPM</u>	<u>1800 RPM</u>	<u>3600 RPM</u>
0.746	82.5	85.5	78.5
1.12	87.5	86.5	85.5
1.49	88.5	86.5	86.5
2.24	89.5	89.5	88.5
3.73	89.5	89.5	89.5
5.60	91.7	91.7	91.0
7.46	91.7	91.7	91.7
11.2	92.4	92.4	91.7
14.9	92.4	93.0	92.4
18.7	93.0	93.6	93.0
22.4	93.6	93.6	93.0
29.8	94.1	94.1	93.6
37.3	94.1	94.5	94.1
44.8	94.5	95.0	94.1
56.9	95.0	95.4	94.5
74.6	95.4	95.4	95.0
93.3	95.4	95.4	95.4
112.0	95.8	95.8	95.4
149.0	95.8	96.2	95.8
187.0	95.6	96.2	95.9
224.0	95.4	96.1	95.8
261.0	94.5	96.2	94.8

298.0	94.5	95.8	94.5
336.0	94.5	94.5	94.5
373.0	94.5	94.5	94.5

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

HP	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0
1.5	86.5	86.5	85.5
2	87.5	86.5	86.5
3	89.5	89.5	86.5
5	89.5	89.5	89.5
7.5	91.7	91.0	89.5
10	91.7	91.7	90.2
15	92.4	93.0	91.0
20	92.4	93.0	92.4
25	93.0	93.6	93.0
30	93.6	93.6	93.0
40	94.1	94.1	93.6
50	94.1	94.5	93.6
60	95.0	95.0	94.1
75	95.0	95.0	94.5
100	95.0	95.4	94.5
125	95.4	95.4	95.0
150	95.8	95.8	95.4
200	95.4	95.8	95.4
250	95.4	96.2	95.8
300	95.4	95.0	95.4
350	94.5	95.4	95.0
400	94.1	95.8	95.0
450	94.5	95.4	95.4
500	94.5	94.5	94.5

TOTALLY ENCLOSED FAN-COOLED MOTORS

HP	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	78.5
1.5	87.5	86.5	85.5
2	88.5	86.5	86.5
3	89.5	89.5	88.5
5	89.5	89.5	89.5
7.5	91.7	91.7	91.0
10	91.7	91.7	91.7
15	92.4	92.4	91.7
20	92.4	93.0	92.4
25	93.0	93.6	93.0
30	93.6	93.6	93.0
40	94.1	94.1	93.6
50	94.1	94.5	94.1
60	94.5	95.0	94.1
75	95.0	95.4	94.5
100	95.4	95.4	95.0
125	95.4	95.4	95.4
150	95.8	95.8	95.4

200	95.8	96.2	95.8
250	95.6	96.2	95.9
300	95.4	96.1	95.8
350	94.5	96.2	94.8
400	94.5	95.8	94.5
450	94.5	94.5	94.5
500	94.5	94.5	94.5

2.13 MOTOR CONTROLS

2.13.1 General

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Panelboards supplying non-linear loads shall have neutrals sized for 200 percent of rated current.

2.13.2 Motor Starters

Combination starters shall be provided with circuit breakers as indicated.

2.13.3 Thermal-Overload Protection

Each motor of 1/8 hp (93 W) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.13.4 Low-Voltage Motor Overload Relays

2.13.4.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or motor controller, and shall be rated in accordance with the requirements of NFPA 70.

2.13.4.2 Construction

Manual reset type thermal relay shall be bimetallic construction. Automatic reset type thermal relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.13.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and

the thermal device is located in an ambient temperature that regularly varies by more than minus 18 degrees F (10 degrees C), an ambient temperature-compensated overload relay shall be provided.

2.13.5 Automatic Control Devices

2.13.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate horsepower rating.

2.13.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.13.5.3 Manual/Automatic Selection

- a. Where combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch (marked MANUAL-OFF-AUTOMATIC) shall be provided for the manual control.
- b. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.
- c. Connections to the selector switch shall be such that; only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.14 PANELBOARDS

Dead-front construction, NEMA PB 1 and UL 67.

2.15 MINI-POWER CENTER (MPC)

- a. General: Transformer, primary, and secondary main circuit breakers, and secondary panel board section enclosed in NEMA 250, Type 31 enclosure.
- b. Transformer:
 1. Type: Dry, self-cooled, encapsulated.

2. Insulation: Manufacturer's standard, with UL 1561 temperature rise.
 3. Full capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.
 4. Primary Voltage: 480, three-phase.
 5. Secondary Voltage: 208/120 volts, three-phase, four-wire.
 6. Rating: 15 kVA.
- c. Panelboard: UL 489, fully-rated.
1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
 2. Number and Breaker Ampere Ratings: Refer to Panelboard Schedule.

2.16 RECEPTACLES

2.16.1 Heavy Duty Grade

NEMA WD 1. Devices shall conform to all requirements for heavy duty receptacles.

2.16.2 Ground Fault Interrupters

UL 943, Class A or B.

2.16.3 NEMA Standard Receptacle Configurations

NEMA WD 6.

- a. Single and Duplex, 20-Ampere, 125 Volt

20-ampere, non-locking: NEMA type 5-20R, locking: NEMA type L5-20R.

- b. 20-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-20R, locking: NEMA type L6-20R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-20R, locking: NEMA type L15-20R.

- c. 30-Ampere, 125/250 Volt

Three-pole, 3-wire, non-locking: NEMA type 10-30R, locking: NEMA type L10-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 14-30R, locking: NEMA type L14-30R.

- d. 30-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-30R, locking: NEMA type L6-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-30R, locking: NEMA type L15-30R.

- e. 50-Ampere, 125/250 Volt

Three-pole, 3-wire: NEMA type 10-50R. Three-pole, 4-wire grounding: NEMA type 14-50R.

f. 50-Ampere, 250 Volt

Two-pole, 3-wire grounding: NEMA type 6-50R. Three-pole, 4-wire grounding: NEMA type 15-50R.

2.17 SERVICE ENTRANCE EQUIPMENT

UL 869A.

2.18 SPLICE, CONDUCTOR

UL 486C.

2.19 POWER-SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS

Assemblies shall be metal-enclosed, freestanding general-purpose type in accordance with NEMA PB 2, UL 891, and IEEE C37.20.1 and shall be installed to provide front and rear access. Busses shall be copper. Assembly shall be approximately 90 inches (2.3 meters) high; arrangement of circuit breakers and other items specified shall be as indicated. The withstand rating and interrupting capacity of the switchgear, switchboards, and circuit breakers shall be based on the maximum fault current available.

2.19.1 Buswork

- a. Material: Phase noninsulated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C (131 degrees F).
- b. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.
- c. Brace for short-circuit currents as shown.
- d. Main Horizontal Bus: Nontapered, continuous current rating as shown.
- e. Neutral Bus: Continuous current rating as shown.
- f. Ground Bus:
 1. Copper.
 2. Rating: 500 amperes.
 3. Bolted to each vertical section.
 4. Bus Connections and Joints: Bolted with Belleville washers.
- g. Extend each bus entire length of switchboard.

2.19.2 Protective Devices

2.19.2.1 Insulated-Case Circuit Breakers

- a. Main Protective Devices Secondary Unit Substation: Fixed, individually mounted, UL 489 listed for 100 percent of continuous ampere rating,

suitable for use with 75 degrees C wire at full 75 degrees C ampacity when mounted in switchboard.

- b. Arrangement: As shown.
- c. Frame Sizes: As shown with solid-state trip units.
- d. Interrupting Rating: As shown.
- e. Selective override circuit having short-time adjustment for selectivity up to rated rms short-time rating.
- f. Two-step, stored energy mechanism with maximum of five cycle closings.
- g. Operation: Manual with multiple charge/close and anti-pump provisions.
- h. Control Power Voltage: Integral.
- i. Operational Sequence: CHARGE-CLOSE-RECHARGE-OPEN-CLOSE-OPEN.
- j. Color-Coded Visual Indicators: Contact OPEN and CLOSE, plus mechanism CHARGE and DISCHARGED.

2.19.2.2 Molded-Case Circuit Breakers

- a. Main and Branch Feeder Protective Devices: Group mounted, suitable for use with 75 degree C wire at full 75 degree C ampacity when mounted in switchboard.
- b. Arrangement: Fully rated main and branch feeder as shown.
- c. Breakers 225-Ampere Frame and Above: Continuously adjustable magnetic pickups five to ten times trip rating.
- d. Breakers 600-Ampere Frame and Above: Solid-state trip unit.
- e. Interrupting Rating: As shown.
- f. Breakers 2,000- through 3,000-Ampere Frame: UL 489 listed and labeled 100 percent application in accordance with NFPA 70.
- g. Mechanical interlock to prevent opening compartment door while breaker is in closed position.

2.19.2.3 Ground Fault Protection

- a. Ground sensor encircling phase conductors and neutral conductor, where used.
- b. Solid-state sensing relay and monitor/test panel.
- c. Zero sequence current detection, adjustable over range shown.
- d. Monitor panel with fault detection indicating light, test, and reset buttons.

- e. Control Power Source: Suitable to operate circuit protective device when connected to faulted phase conductor.

2.19.2.4 Solid-State-Trip Unit

- a. Flux-shift trip and current sensors.
- b. Protective Programmers:
 - 1. Self-powered, automatic RMS sensing micro-electronic processor.
 - 2. No external relays or accessories.
 - 3. Printed circuit cards with gold-plated contacts.
 - 4. Programmable Controls:
 - a) Fixed-point, with repetitive accuracy and precise unit settings.
 - b) Trip adjustments made by nonremovable, discrete step switching.
 - 5. Field-Installable Rating Plugs:
 - a) Long-time pickup LED indicator and test receptacle.
 - b) Matching load and cable requirements.
 - c) Interlocked with tripping mechanism.
 - d) Breaker to remain trip-free with plug removed.
 - e) Keyed rating plugs to prevent incorrect application.
 - 6. Long-time pickup light.
 - 7. Selective Coordination Time/Current Curve Shaping Adjustable Functions:
 - a) Current setting.
 - b) Long-time pickup.
 - c) Long-time delay.
 - d) Instantaneous pickup with short-time for main and feeders.
 - e) Short-time pickup for main and feeders.
 - g) Ground fault pickup.
 - h) Ground fault delay with I²T function.
 - i) High instantaneous pickup with short-time delay.
 - j) Zone selective interlock.

8. Fault Trip Indicators: Mechanical push-to-reset type for overload and short-circuit overload plus ground fault trip.
 9. Rejection Pins: For each programmer frame size.
 - c. Phase Current Sensors:
 1. Single-ratio type.
 2. Fixed, mounted on breaker frame.
 3. Molded epoxy construction.
 4. One toroidal type for each phase.
- 2.20 CONTROL WIRING
- a. Control, Instrumentation, and Power/Current Circuits: NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.
 - b. Transducer Output/Analog Circuits: Shielded cable rated 600 volts, 90 degrees C (194 degrees F) minimum.
 - c. Conductor Lugs: Preinsulated, self-locking, spade-type, with reinforced sleeves.
 - d. Identification: Individually, with permanent wire markers at each end.
 - e. Enclose in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.
 - f. Splices: Not permitted in switchboard wiring.
- 2.21 TERMINAL BLOCKS
- a. Enclosed in steel wiring troughs.
 - b. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.
 - c. Shorting type for current transformer leads.
 - d. Provide terminal blocks for:
 1. Conductors connecting to circuits external to switchboard.
 2. Internal circuits crossing shipping splits.
 3. Equipment parts requiring replacement and maintenance.
 - e. Spare Terminals: Not less than 20 percent.
 - f. Group terminal blocks for external circuit wiring leads.
 - g. Maintain 6-inch (15.24 cm) minimum space between columns of terminal blocks.

h. Identification: Permanent, for each terminal and columns of terminal blocks.

i. Manufacturer: General Electric; Type EB-5.

2.22 TAPES

2.22.1 Plastic Tape

UL 510.

2.22.2 Rubber Tape

UL 510.

2.23 DRY TYPE TRANSFORMERS

Single- and three-phase transformers shall have two windings per phase. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers unless otherwise indicated. Three-phase transformers shall be configured with delta-wye windings, except as indicated. "T" connections may be used for transformers rated 15 kVA or below. Transformers supplying non-linear loads shall be UL listed as suitable for supplying such loads with a total K-factor not to exceed K-9 and have neutrals sized for 200 percent of rated current.

2.23.1 Transformers, Dry-Type

Transformers shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation system for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient temperature of 40 degrees C. Transformer of 150 degrees C temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating.

a. 600 Volt or Less Primary:

NEMA ST 20, UL 506, general purpose, dry-type, self-cooled, ventilated. Transformers shall be provided in NEMA 1 enclosure except NEMA 3R where exterior to the building. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.23.2 Average Sound Level

The average sound level in decibels (dB) of transformers shall not exceed the following dB level at 12 inches (300 mm) for the applicable kVA rating range listed unless otherwise indicated:

kVA Range	dB Sound Level
1-50	50
51-150	55
151-300	58
301-500	60

501-700	62
701-1000	64
1001-1500	65
1501 & above	70

2.24 WIRING DEVICES

NEMA WD 1 for wiring devices, and NEMA WD 6 for dimensional requirements of wiring devices.

2.25 POWER CONDITIONERS

2.25.1 Summary

These specifications describe requirements for power conditioners and associated distribution panels, supplying computer-grade power to sensitive loads. The specified system shall provide isolation, regulation, noise and transient suppression, distribution, control, and monitoring of AC power. It shall include all equipment to properly interface the AC power source to the intended load.

2.25.2 System Description

2.25.2.1 Electrical Requirements

- a. Output capacity of each conditioner shall be 100 kVA and 100 kW.
- b. Input voltage shall be 208 volts AC, 60 Hz, three-phase, three-wire-plus-ground.
- c. Output voltage shall be 208/120 volts AC, 60 Hz, three-phase, four wire-plus-ground, wye configuration.

2.25.2.2 Environmental Requirements

- a. The storage temperature range shall be -55 degrees C to +85 degrees C (-67 degrees F to +185 degrees F).
- b. The operating temperature range shall be 0 degrees C to 40 degrees C (+32 degrees F to 104 degrees F).
- c. Operation shall be reliable in an environment with 0 percent to 95 percent noncondensing relative humidity.
- d. The audible noise level of the specified system shall be less than 63 dBA at 5 feet (1.5 m).

2.25.3 Components

2.25.3.1 Frame Construction and Enclosure

The frame shall be constructed of welded steel to provide a strong substructure and ensure grounding integrity. The enclosure shall be designed with a welded steel base so that the unit can be moved by fork-lift equipment and set flat on the floor without the use of a floorstand. A tool shall be required to remove the panels that access the hazardous voltage

area of the unit. Hinged doors shall provide access for operation of the main input circuit breaker and output circuit breaker(s).

The complete specified system shall have maximum dimensions of: width, 66 inches (1676 mm) 100-125 kVA systems, depth, 36 inches (914 mm); height, 76 inches (1930 mm). Exterior panels shall be removable to allow the unit to fit through a 34-inch (864 mm) doorway. The distributed floor weight shall be a maximum of 300 lbs/sq. ft. (1465 kg/sq.m). Multiple redundant cooling fans (n + 1) shall allow continuous full load operation at the maximum specified temperature without overtemperature.

2.25.3.2 Input Connections

- a. Power: Terminals shall be provided for the incoming AC power and ground. The power connections shall be designed to accept wire sizes commensurate with the input circuit breaker:
 1. 300 - 600 A; (2) #2/0 - 400 kcmil
- b. Control: The low-voltage input shall contain a terminal block with at least 21 positions for connecting all building interface alarms, controls, and Remote Emergency Power Off (REPO) switches. The low-voltage section shall also contain a 24 VDC, DPDT building interface relay for interfacing with environmental systems, alarm panels, etc. The relay contacts shall be rated for use at up to 10 amps at 240 VAC.
- c. Main Input Circuit Breaker: The specified unit shall be equipped with a main input circuit breaker to provide overcurrent protection and a means for disconnecting power to the unit. The main input circuit breaker shall be a three-pole molded case circuit breaker sized for at least 125 percent of the specified full load input current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be (25,000) RMS symmetrical amperes at 480 volts AC. The main input circuit breaker shall include a 24 VDC shunt trip mechanism to interface with EPO switches and other system controls.
- d. Magnetic Synthesizer/Regulator: Power conditioning shall be accomplished by using a magnetic synthesizer/regulator. The magnetic synthesizer/regulator shall be a static electromagnetc 3-phase AC power regenerator and shall not contain mechanically moving parts, power semi-conductors or feedback control circuits. The following shall be typical characteristics exhibited by the magnetic synthesizer/regulator:
 1. Static Voltage Regulation (for any load condition, no load to full load): For nominal input voltage, the output voltage shall be within nominal to +/-3 percent. For input voltage variation of ~~+40~~ +15 percent to ~~-40~~ -15 percent of nominal, minimum range, the output voltage shall be within +5 percent to -5 percent.
 2. Unbalanced Load: At nominal input voltage, and with 100 percent load imbalance, output voltage shall be within +5 percent and -2 percent.
 3. Overload: At nominal input voltage, while increasing the load from full to 200 percent of full load, the output voltage shall be no less that -6 percent of nominal. The unit shall be capable of

sustaining 200 percent load until activation of the overcurrent protection, typically 3 to 20 minutes.

4. Input Transients: No power disturbances shall be evident on the output when high-energy ringing transients are impressed on the input lines. The specified system shall protect against surges as defined by ANSI/IEEE Standards C62.41 and C62.45.
5. Electrical Noise Suppression: Common mode noise suppression shall be 120 dB minimum. Normal mode noise suppression shall be 120 dB minimum.
6. Unbalanced Input Voltage (Single-Phasing): Upon loss of one phase of input voltage, ~~output phase voltages shall remain within +5.8 percent to -4 percent of nominal from no load to 60 percent load the input circuit breaker shall trip.~~
7. Short-Circuit Capability: ~~The sustained A short-circuit current of shall be limited to 300 percent of full load. This current output~~ shall be sustained without damage, until the overcurrent protection is activated.
8. Harmonic Distortion (No load to full load): The output voltage total harmonic distortion shall be less than 4 percent. Input voltage distortion shall not be added to the output voltage distortion.
9. Efficiency: At nominal input voltage, the efficiency of the system shall be 93 percent at full load, 91.5 percent at three quarter load, and 89 percent at half load.
10. Power Factor: The input power factor of the magnetic synthesizer/regulator shall be nearly unity under all load conditions from half to full load. The full load input power factor shall be 0.96 lagging, or better. The input power factor shall be independent of the load power factor.
11. Input Current: The magnetic synthesizer/regulator shall draw linear input current from no load to full load. Input current distortion shall be less than 8 percent THD, independent of output current distortion.
12. Output ~~Impedance~~Characteristics: A 3-phase bank of capacitors shall be directly connected access the output of the magnetic synthesizer/regulator for low output impedance. The output capacitance shall attenuate load generated noise and transients, as well as supply the non-linear current requirements of modern computer equipment without causing excessive output voltage distortion. The manufacturer may utilize alternative means to provide these characteristics, at their option (e.g., via the use of Input Transient Suppression hardware and/or appropriate transformer shielding).

The magnetic synthesizer/regulator shall be provided with additional thermal overload protection for the transformers. An alarm shall sound if any transformer temperature reaches 160 degrees C. The system shall

automatically shut down if any transformer temperature reaches 180 degrees C.

- e. Manual Restart: A manual restart circuit shall allow for an orderly supervised startup after power failure. The control circuit shall automatically energize the shunt trip mechanism of the main input breaker upon sensing output voltage failure. A field-selectable auto-restart mode shall be provided to deactivate the manual restart if desired.
- f. Emergency Power Off (EPO): The local EPO shall include a fully guarded and illuminated "EMERGENCY POWER OFF" pushbutton. Pressing the EPO switch shall immediately shut down the system by activating the shunt trip of the main input circuit breaker. As part of the EPO circuit, an interface shall also be provided for connecting normally open or normally closed remote EPO switches to the EPO circuit. For flexibility in meeting shutdown control schemes, the local EPO (unit shutdown) circuit shall be isolated from the remote EPO (room shutdown) circuit. The remote EPO circuit shall be designed to allow direct connection of multiple units with single and/or multiple shutdown control contacts.
- g. Computer-Grade Ground: A computer-grade, single-point ground shall be provided in accordance with computer manufacturer's recommendations, IEEE Std. 1100, and the requirements of the NEC. The synthesizer/regulator output neutral shall be solidly grounded in accordance with NEC article 250-26.

2.25.3.3 Self-Contained System

The self-contained system shall also include:

- a. Output Distribution Panelboards: The specified system shall contain four vertically mounted output panelboards for distribution to the intended loads. Each output distribution panelboard shall be individually protected by a main panelboard circuit breaker. Each panelboard shall be individually enclosed with a separate cover which provides access to that panelboard without exposing other portions of the unit. The panelboard shall have a rating of 225 amperes, with an overall short-circuit current rating of 10,000 RMS symmetrical amperes. The panelboards shall provide a total of 120 single-pole branch circuit breaker positions. Each panel board shall include separate isolated neutral and safety-ground bus bars for the neutral and safety-ground connections from each branch load. Each neutral bus bar and wiring shall be rated for at least 1.73 times the full load rating of the panelboard to accommodate high neutral currents associated with single-phase nonlinear loads.
- b. Branch Circuit Breakers: Each load shall be protected by an individual branch circuit breaker. Each panel shall be fully equipped with 20-amp single-pole breakers in each position, with exception to a 125-amp, 3-pole breaker in SPCP-4 to feed panel SSP. Each branch circuit breaker shall provide overcurrent protection and "ON-OFF" switching to the specified load. Single-pole, two pole and three pole bolt-in type branch circuit breakers up through 100 amperes shall be utilized. Each circuit breaker shall clearly identify the "ON", the "OFF", and the "TRIPPED" positions. All branch circuit breakers shall have a minimum interrupting capacity of 10,000 RMS symmetrical amperes at 120/240 VAC.

Each branch circuit breaker shall be sized in accordance with the NEC and shall be UL/CSA listed. Branch circuit breakers shall have an associated directory label, located adjacent to the breaker, identifying the branch circuit number and the equipment being served.

2.25.3.4 Power Monitoring System

The specified system shall be equipped with a microprocessor-based Power Monitor Panel. The monitor panel shall gather and process information from electrical and environmental sensors, relays, and switches both internal and external to the unit. The monitored parameters and alarms shall be displayed on the unit monitor panel, and shall also be available for communication to a ~~Liebert~~-centralized site monitoring system using a two-wire, twisted-pair, low-voltage signal circuit having an RS-422 format for reliable communication up to 1000 meters. Additionally, the monitor panel shall be equipped with an RS-232 service port for adjusting parameters and performing diagnostics.

a. Monitored Parameters:

1. The monitoring system shall monitor and display all of the following parameters:
 - a) Input Voltages, Line-to-Line for all three phases.
 - b) Output Voltages, Line-to-Line for all three phases.
 - c) Output Voltages, Line-to-Neutral for all three phases.
 - d) Output Current for all three phases.
 - e) Output Neutral Current.
 - f) System Ground Current.
 - g) Output Frequency.
 - h) Output kVA.
 - i) Output kW.
 - j) Output Power Factor.
 - k) Percent Load.
2. All three phases of the three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate representation of non-sinusoidal waveforms typical of computers and other sensitive loads.

b. Alarm Annunciation:

1. The monitoring system shall detect and annunciate by audible alarm and displayed alarm message the following conditions:
 - a) Output Overvoltage
 - b) Output Undervoltage
 - c) Output Overload
 - d) Neutral Overcurrent
 - e) Ground Overcurrent
 - f) Transformer Overtemperature
 - g) Frequency Deviation
 - h) Phase Sequence Error
 - i) Phase Loss

2. All alarm thresholds for monitored parameters shall be adjustable by the way of the service port to match site requirements. The factory setpoints for the alarms shall be as follows:
 - a) Output Overvoltage: Output voltage exceeds +6 percent of nominal.
 - b) Output Undervoltage: Output voltage falls below -13 percent of nominal.
 - c) Output Overload: Output current exceed 95 percent of full load amps.
 - d) Neutral Overcurrent: Neutral current exceeds 95 percent of full load amps.
 - e) Ground Overcurrent: Ground current exceeds 5 amps.
 - f) Frequency Deviation: Output frequency exceeds +/-0.5 Hz of nominal.

To facilitate troubleshooting, all alarms shall be stored in battery-backed (non-volatile) memory until reset to protect against erasure by a power outage. Alarms shall be able to be manually reset, either at the unit or through the centralized site monitoring system, after the alarm condition has been corrected.

- c. Custom Alarm Annunciation: The monitoring system shall be capable of providing alarm annunciation for up to five contact closures (4 N.O. and 1 N.C.). A custom alarm message of up to 20 characters shall be provided for each contact. Alarm messages shall be programmable by way of the service port to match site requirements.
- d. Summary Alarm Contact: A form C (1 N.O. and 1 N.C.) Summary Alarm Contact shall be provided for remote alarm status. The contacts shall change state upon occurrence of any alarm and shall reset upon alarm silence.
- e. Display:
 1. All monitored parameters and alarm messages shall be displayed on a 4 x 20 character, high-visibility liquid crystal display (LCD) located on the unit front door within a decorative bezel. Included in the bezel shall be an Identifying Unit Number, Emergency Power Off (EPO) switch, and an Alarm Present/Silence switch.
 2. The Alarm Present/Silence switch shall be illuminated upon occurrence of any alarm and remain illuminated until all alarms are reset. The switch shall also be used to silence the audible alarm and reset inactive alarms.
- f. Autoscan: For ease of operation, the monitoring system shall include an autoscan mode which provides continuous sequential display of all monitored parameters and active alarm messages. A Hold/Sequence switch shall be provided to interrupt the autoscan mode and allow manual selection of the displayed parameters.

2.25.3.5 Accessories

a. Bypass Switch (General Requirements):

1. The bypass switch shall be UL recognized 4-pole, double-throw, break-before-make switch rated for industrial use, with a continuous current rating of at least 125 percent of the full load output amps. The bypass switch shall switch the output phases and neutral simultaneously for complete isolation of the magnetic synthesizer/regulator. The switch shall allow the output to be powered from either the magnetic synthesizer/regulator or from the reserve input.

b. ~~a.~~ Bypass Switch (Option #1):

1. The unit shall be equipped with a bypass circuit for manually removing the magnetic synthesizer/regulator from the power path. The bypass circuit shall include a reserve input power connection, a reserve input breaker, and a bypass switch. The unit shall contain power terminals for connection of the incoming AC power. The reserve input power connections shall be designed to accept a wire size commensurate with the reserve input breaker rating.
2. The reserve input breaker shall be a 3-pole molded-case circuit breaker, providing overcurrent protection and a means for disconnecting power to the bypass circuit. The circuit breaker shall be rated for 600 VAC and sized for 125 percent of the bypass circuit full load input circuit in accordance with the NEC. The minimum UL-listed interrupting rating for the reserve input circuit breaker shall be (25,000) RMS symmetrical amperes at 480 VAC. The reserve input circuit breaker shall include a 24VDC shunt trip mechanisms to interface with EPO switches and other system controls.

- ~~3. The bypass switch shall be UL recognized 4 pole, double throw, break before make switch rated for industrial use, with a continuous current rating of at least 125 percent of the full load output amps. The bypass switch shall switch the output phases and neutral simultaneously for complete isolation of the magnetic synthesizer. The switch shall allow the output to be powered from either the magnetic synthesizer or from the reserve input.~~

c. Bypass Switch (Option #2):

1. As an alternative to Option #1, an automatic bypass switch shall be provided. The bypass switch shall transfer automatically upon catastrophic internal electronics failure to maintain supply of output power to the load.

2.25.4 Floor Pedestals

Floor pedestals shall be furnished to level the unit and to provide bottom cabling access without relying upon a raised floor for support. The nominal height of the floor pedestals shall be a minimum of 6 inches (152 mm) and a maximum of 8 inches (203 mm); with adjustments for a minimum of +/-3 inches (76 mm).

2.26 MANUAL TRANSFER SWITCH

- a. Transfer switch consisting of inherently double-throw power switch.

- b. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads. Switches rated above 400 amperes suitable for 30 percent tungsten-filament lamp loads
- c. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.
- d. Suitable for 480/277 volts, three-phase, four-wire, grounded-wye electrical service having an available short circuit at line terminals of 65,000 amperes rms symmetrical.
- e. Switch Rating: 600 amperes rating in nonventilated enclosure.
- f. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.
- g. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- h. Operating Conditions:
 - 1. Ambient Temperature: Maximum 50 degrees C.
 - 2. Equipment to be fully rated without any derating for operating conditions listed above.
- i. Locking mechanism to maintain constant contact pressure.
- j. Silver alloy contacts protected by arcing contacts.
- k. Nonventilated NEMA 250, Type I with enclosure grounding terminal.
- l. Dead front, front accessible floor mounted cabinet with 14-gauge welded steel construction.
- m. Continuously hinged single door, with handle and lock cylinder.
- n. Finish: Baked enamel applied over rust-inhibiting, phosphate base coating.
 - 1. Exterior and Interior Color: Provide gray finish.
 - 2. Unpainted Metal Parts: Plated for corrosion resistance.

2.27 FAULT CURRENT AND PROTECTIVE DEVICE COORDINATION STUDY

Analyses shall be prepared to demonstrate that the equipment and system constructed meet the specified requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.27.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.27.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. The Contractor shall utilize the fault current availability indicated as a basis for fault current studies.

2.27.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provide, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.27.4 Fault Current Analysis

2.27.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.27.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.27.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.27.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situation where system coordination is not achievable due to device limitations (an analysis of any device curves which order overlap); coordination between upstream and downstream

devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.27.6 Study Report

- a. The report shall include a narrative: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.
- c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device curves and protective device ratings and settings.
- d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.
- e. The report shall provide the calculations performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and Section 16665, GROUNDING.

3.2 WIRING METHODS

Wiring shall conform to NFPA 70, the contract drawings, and the following specifications. Unless otherwise indicated, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit, rigid plastic conduit, and electrical metallic tubing. Where cables and wires are installed in cable trays, they shall be of the type permitted by NFPA 70 for use in such applications. Wire fill in conduits shall be based on NFPA 70 for the type of conduit and wire insulations specified.

3.2.1 Conduit and Tubing Systems

Conduit and tubing systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in paragraph WIRING METHODS. Minimum size of raceways shall be 1/2 inch (15 mm). Only metal conduits will be permitted when conduits are

required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit and tubing may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduit or tubing system is provided with appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Electrical metallic tubing (EMT) may be installed only within buildings. EMT may not be installed in concrete and grout in dry locations. EMT shall not be installed in damp or wet locations, or the air space of exterior masonry cavity walls. Bushings, manufactured fittings or boxes providing equivalent means of protection shall be installed on the ends of all conduits and shall be of the insulating type, where required by NFPA 70. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped in accordance with Section 07840 FIRESTOPPING. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 6 inches (150 mm) away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints or seismic joints shall be provided with suitable expansion fittings or other suitable means to compensate for the building expansion and contraction and to provide for continuity of grounding. Wiring installed in underfloor duct system shall be suitable for installation in wet locations.

3.2.1.1 Pull Wires

A pull wire shall be inserted in each empty raceway in which wiring is to be installed if the raceway is more than 50 feet (15 meters) in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 150 feet (45 meters) in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 200 pounds per square inch (1.4 MPa) tensile strength. Not less than 10 inches (254 mm) of slack shall be left at each end of the pull wire.

3.2.1.2 Conduit Stub-Ups

Where conduits are to be stubbed up through concrete floors, a short elbow shall be installed below grade to transition from the horizontal run of conduit to a vertical run. A conduit coupling fitting, threaded on the inside shall be installed, to allow terminating the conduit flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit may be used 6 inches (150 mm) above the floor. Empty or spare conduit stub-ups shall be plugged flush with the finished floor with a threaded, recessed plug.

3.2.1.3 Below Slab-on-Grade or in the Ground

Electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit passing vertically through slabs-on-grade shall be rigid steel or rigid plastic conduit. Rigid steel or rigid plastic conduits installed below slab-on-grade or in the earth shall be field wrapped with 0.010 inch (0.254 mm) thick pipe-wrapping plastic tape applied with a 50 percent overlay, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system.

3.2.1.4 Installing in Slabs Including Slabs on Grade

Conduit installed in slabs-on-grade shall be rigid steel or rigid plastic conduit. Conduits shall be installed as close to the middle of concrete slabs as practicable without disturbing the reinforcement. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Contracting Officer. Where conduit is run parallel to reinforcing steel, the conduit shall be spaced a minimum of one conduit diameter away but not less than one inch (25.4 mm) from the reinforcing steel.

3.2.1.5 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment shall be prevented during the course of construction. Clogged raceways shall be cleared of obstructions or shall be replaced.

3.2.1.6 Supports

Metallic conduits and tubing, and the support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 10 feet (3 meters) and within 3 feet (900 mm) of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, beam clamps, or ceiling trapeze. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structure. Loads shall not be applied to joist bridging. Attachment shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or pipe straps shall not be welded to steel structures. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported using wire or nylon ties. Raceways shall be independently supported from the structure. Upper raceways shall not be used as a means of support for lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Cables and raceways shall not be supported by ceiling grids. Except where permitted by NFPA 70, wiring shall not be supported by ceiling support systems. Conduits shall be fastened to sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. Additional support for horizontal runs is not required when EMT rests on steel stud cutouts.

3.2.1.7 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations in accordance with NFPA 70 definitions.

3.2.1.8 Exposed Risers

Exposed risers in wire shafts of multistory buildings shall be supported by U-clamp hangers at each floor level, and at intervals not to exceed 10 feet (3 meters).

3.2.1.9 Exposed Lengths of Conduit, Over 600 Volts

Exposed lengths of conduit containing power conductors operating at more than 600 volts shall have two red bands 2 inches (50 mm) wide spaced 8 inches (200 mm) apart painted near each coupling; the intervening space between the red bands shall be painted white, and on the white space the voltage shall be stenciled in black the line-to-line voltage of the system.

3.2.1.10 Communications Raceways

Communications raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirement that no length of run shall exceed 50 feet (15 meters) for 1/2 inch (15 mm) and 3/4 inch (20 mm) sizes, and 100 feet (30 meters) for 1 inch (25 mm) or larger sizes, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends in conduits of 1 inch (25 mm) size or larger shall not be less than ten times the nominal diameter.

3.2.2 Busway Systems

Busway systems shall be of the voltage, capacity, and phase characteristics indicated. Vertical runs of busways within 6 feet (1.8 meters) of the floor shall have solid enclosures. Busways shall be supported at intervals not exceeding 5 feet (1.5 meters), and shall be braced properly to prevent lateral movement. Busways penetrating walls or floors shall be provided with flanges to completely close wall or floor openings.

3.2.3 Cable Trays

Cable trays shall be supported in accordance with the recommendations of the manufacturer but at no more than 6 foot (1.8 meter) intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. The Contractor shall submit the manufacturer's certification that the cable tray system meets all requirements of Article 318 of NFPA 70. The cable tray shall be installed and grounded in accordance with the provisions of Article 318 of NFPA 70. Data submitted by the Contractor shall demonstrate that the completed cable tray systems will comply with the specified requirements. Cable trays shall be provided with fire pillows within the tray at smoke and fire partitions. The installation shall be sealed to preserve the smoke and fire rating of the partitions.

Penetrations shall be firestopped in accordance with Section 07840
FIRESTOPPING.

3.2.4 Cables and Conductors

Installation shall conform to the requirements of NFPA 70. Covered, bare or insulated conductors of circuits rated over 600 volts shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts or less.

3.2.4.1 Sizing

Unless otherwise noted, all sizes are based on copper conductors and the insulation types indicated. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 100 feet (30 meters) long and of 277 volts more than 230 feet (70 meters) long, from panel to load center, shall be no smaller than No. 10 AWG. Class 1 remote control and signal circuit conductors shall be not less than No. 14 AWG. Class 2 remote control and signal circuit conductors shall be not less than No. 16 AWG. Class 3 low-energy, remote-control and signal circuits shall be not less than No. 22 AWG.

3.2.4.2 Conductor Identification and Tagging

Power, control, and signal circuit conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation. Phase conductors of low voltage power circuits shall be identified by color coding. Phase identification by a particular color shall be maintained continuously for the length of a circuit, including junctions.

- a. Color coding shall be provided for service, feeder, branch, and ground conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in the same raceway or box, other neutral shall be white with colored (not green) stripe. The color coding for 3-phase and single-phase low voltage systems shall be as follows:

120/208-volt, 3-phase: Black(A), red(B), and blue(C).
277/480-volt, 3-phase: Brown(A), orange(B), and yellow(C).
120/240-volt, 1-phase: Black and red.

- b. Conductor phase and voltage identification shall be made by color-coded insulation for all conductors smaller than No. 6 AWG. For conductors No. 6 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 3 inches (75 mm) of length near the end, or other method as submitted by the Contractor and approved by the Contracting Officer.

- c. Control and signal circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems where required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers. Indicated elevations are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70. Unless otherwise indicated, boxes for wall switches shall be mounted 48 inches (1.2 meters) above finished floors. Switch and outlet boxes located on opposite sides of fire rated walls shall be separated by a minimum horizontal distance of 24 inches (600 mm). The total combined area of all box openings in fire rated walls shall not exceed 100 square inches (0.0645 square meters) per 100 square feet (9.3 square meters). Maximum box areas for individual boxes in fire rated walls vary with the manufacturer and shall not exceed the maximum specified for that box in UL Elec Const Dir. Only boxes listed in UL Elec Const Dir shall be used in fire rated walls.

3.3.1 Box Applications

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways shall be listed for the intended use when located in normally wet locations, when flush or surface mounted on outside of exterior surfaces, or when located in hazardous areas. Boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Boxes for mounting lighting fixtures shall be not less than 4 inches (102 mm) square, or octagonal, except smaller boxes may be installed as required by fixture configuration, as approved. Cast-metal boxes with 3/32 inch (2.4 mm) wall thickness are acceptable. Large size boxes shall be NEMA 12 or as shown. Boxes in other locations shall be sheet steel except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit and tubing or nonmetallic sheathed cable system, when permitted by NFPA 70. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers.

3.3.2 Brackets and Fasteners

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screw or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. Penetration of more than 1-1/2 inches (38.1 mm) into reinforced-concrete beams or more than 3/4 inch (19.1 mm) into reinforced-concrete joists shall avoid cutting any main reinforcing steel. The use of brackets which depend on gypsum wallboard or plasterboard for primary support will not be permitted. In partitions of light steel construction, bar hangers with 1

inch (25 mm) long studs, mounted between metal wall studs or metal box mounting brackets shall be used to secure boxes to the building structure. When metal box mounting brackets are used, additional box support shall be provided on the side of the box opposite the brackets. This additional box support shall consist of a minimum 12 inch (300 mm) long section of wall stud, bracketed to the opposite side of the box and secured by two screws through the wallboard on each side of the stud. Metal screws may be used in lieu of the metal box mounting brackets.

3.3.3 Mounting in Walls, Ceilings, or Recessed Locations

In walls or ceilings of concrete, tile, or other non-combustible material, boxes shall be installed so that the edge of the box is not recessed more than 1/4 inch (6 mm) from the finished surface. Boxes mounted in combustible walls or ceiling material shall be mounted flush with the finished surface. The use of gypsum or plasterboard as a means of supporting boxes will not be permitted. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be mounted flush with the top of a block to minimize cutting of the blocks, and boxes shall be located horizontally to avoid cutting webs of block. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

3.3.4 Installation in Overhead Spaces

In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 24 inches (600 mm) from the box.

3.4 DEVICE PLATES

One-piece type device plates shall be provided for all outlets and fittings. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, cast-metal, or impact resistant plastic having rounded or beveled edges. Plates on finished walls shall be of steel with baked enamel finish or impact-resistant plastic and shall be ivory, satin finish corrosion resistant steel or satin finish chromium plated brass. Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch (1.6 mm). The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

3.5 RECEPTACLES

3.5.1 Single and Duplex, 15 or 20-ampere, 125 volt

Single and duplex general purpose receptacles shall be rated 20 amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be of ivory to match color of switch handles in the same room or to harmonize with the color of the respective wall, and supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke. Switched receptacles shall be the same as other receptacles specified except that the ungrounded pole of each suitable receptacle shall be provided with a separate terminal. Only the top receptacle of a duplex receptacle shall be wired for switching application. Receptacles with ground fault circuit interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

3.5.2 Clock Outlet

Clock outlet, for use in other than a wired clock system, shall consist of an outlet box, a plaster cover where required, and a single receptacle with clock-outlet plate. The receptacle shall be recessed sufficiently within the box to allow the complete insertion of a standard cap, flush with the plate. A suitable clip or support for hanging the clock shall be secured to the top of the plate. Material and finish of the plate shall be as specified in paragraph DEVICE PLATES.

3.5.3 Weatherproof Applications

Weatherproof receptacles shall be suitable for the environment, damp or wet as applicable, and the housings shall be labeled to identify the allowable use. Receptacles shall be marked in accordance with UL 514A for the type of use indicated; "Damp locations", "Wet Locations", "Wet Location Only When Cover Closed". Assemblies shall be installed in accordance with the manufacturer's recommendations.

3.5.3.1 Damp Locations

Receptacles in damp locations shall be mounted in an outlet box with a gasketed, weatherproof, cast-metal cover plate (device plate, box cover) and a gasketed cap (hood, receptacle cover) over each receptacle opening. The cap shall be either a screw-on type permanently attached to the cover plate by a short length of bead chain or shall be a flap type attached to the cover with a spring loaded hinge.

3.5.3.2 Wet Locations

Receptacles in wet locations shall be installed in an assembly rated for such use whether the plug is inserted or withdrawn, unless otherwise indicated. In a duplex installation, the receptacle cover shall be configured to shield the connections whether one or both receptacles are in use. Assemblies which utilize a self-sealing boot or gasket to maintain wet location rating shall be furnished with a compatible plug at each receptacle

location and a sign notifying the user that only plugs intended for use with the sealing boot shall be connected during wet conditions.

3.5.4 Receptacles, 15-Ampere, 250-Volt

Receptacles, 15-ampere, 250-volt, shall be single two-pole, three-wire, grounding type with bodies of as indicated phenolic compound supported by mounting yoke having plaster ears. The third grounding pole shall be connected to the metal yoke. Each receptacle shall be provided with a mating cord-grip plug.

3.5.5 Receptacles, 20-Ampere, 250-Volt

Receptacles, single, 20-ampere, 250-volt, shall be as indicated molded plastic, two-pole, three-wire or three-pole, four-wire, grounding type complete with appropriate mating cord-grip plug.

3.5.6 Receptacles, 30-Ampere, 250-Volt

Receptacles, single, 30-ampere, 250-volt, shall be molded-plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.7 Receptacles, 50-Ampere, 250-Volt

Receptacles, single, 50-ampere, 250-volt, shall be flush molded plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.8 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles indicated or required for the anticipated purpose. Contact surfaces may be either round or rectangular. One appropriate straight or angle-type plug shall be furnished with each receptacle. Locking type receptacles, rated 30 amperes or less, shall be locked by rotating the plug. Locking type receptacles, rated more than 50 amperes, shall utilize a locking ring.

3.6 WALL SWITCHES

Wall switches shall be of the totally enclosed tumbler type. The wall switch handle and switch plate color shall be ivory. Wiring terminals shall be of the screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than one switch shall be installed in a single-gang position. Switches shall be rated 20-ampere 277-volt for use on alternating current only. Pilot lights indicated shall consist of yoke-mounted candelabra-base sockets rated at 75 watts, 125 volts, and fitted with glass or plastic jewels. A clear 6-watt lamp shall be furnished and installed in each pilot switch. Jewels for use with switches controlling motors shall be green, and jewels for other purposes shall be red. Dimming switches shall be solid-state flush mounted, sized for the loads.

3.7 SERVICE EQUIPMENT

Service-disconnecting means shall be of the type indicated in paragraph POWER SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS with an external handle

for manual operation. When service disconnecting means is a part of an assembly, the assembly shall be listed as suitable for service entrance equipment. Enclosures shall be sheet metal with hinged cover for surface mounting unless otherwise indicated.

3.8 PANELBOARDS

Circuit breakers and switches used as a motor disconnecting means shall be capable of being locked in the open position. Door locks shall be keyed alike. Nameplates shall be as approved. Directories shall be typed to indicate loads served by each circuit and mounted in a holder behind a clear protective covering. Busses shall be copper.

3.8.1 Panelboards

Panelboards shall be circuit breaker or fusible switch equipped as indicated on the drawings. Multipole fusible switches shall be of the hinged-door type; single pole fusible switches shall be of the tumbler switch and fuse type. Switches serving as a motor disconnect means shall be of the tumbler switch and fuse type. Switches serving as motor disconnect means shall be horsepower rated in conformance with UL 98.

3.9 FUSES

Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilize fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics required for effective power system coordination. Time-delay and non-time-delay options shall be as shown.

3.9.1 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds.

3.9.2 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class G, J, K, L, RK1, and CC shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject all Class H fuses.

3.9.3 Continuous Current Ratings (600 Amperes and Smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK1, current-limiting, nontime-delay with 200,000 amperes interrupting capacity.

3.9.4 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

3.10 MOTORS

Each motor shall conform to the hp and voltage ratings indicated, and shall have a service factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts. Unless otherwise specified, all motors shall have open frames, and continuous-duty classification based on a 40 degree C ambient temperature reference. Polyphase motors shall be squirrel-cage type, having normal-starting-torque and low-starting-current characteristics, unless other characteristics are specified in other sections of these specifications or shown on contract drawings. The Contractor shall be responsible for selecting the actual horsepower ratings and other motor requirements necessary for the applications indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.11 MOTOR CONTROL

Each motor or group of motors requiring a single control and not controlled from a motor-control center or individual combination motor starter shall be provided under other sections of these specifications with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 1/8 hp (93 W) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit. When combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC

switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

3.11.1 Contacts

Unless otherwise indicated, contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

3.11.2 Safety Controls

Safety controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.12 MOTOR-DISCONNECT MEANS

Each motor shall be provided with a disconnecting means when required by NFPA 70 even though not indicated. For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

3.13 TRANSFORMER INSTALLATION

Three-phase transformers shall be connected only in a delta-wye or wye-delta configuration as indicated. "T" connections may be used for transformers rated at 15 kVA or below. Dry-type transformers shown located within 5 feet (1.5 meters) of the exterior wall shall be provided in a weatherproof enclosure. Transformers to be located within the building may be provided in the manufacturer's standard, ventilated indoor enclosure designed for use in 40 degrees C ambient temperature, unless otherwise indicated.

3.14 LIGHTING FIXTURES, LAMPS AND BALLASTS

This paragraph shall cover the installation of lamps, lighting fixtures and ballasts in interior or building mounted applications.

3.14.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15% of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. 10% spare lamps of each type, from the original manufacturer, shall be provided.

3.14.2 Lighting Fixtures

Fixtures shall be as shown and shall conform to the following specifications and shall be as detailed on the drawings. Illustrations shown on the drawings are indicative of the general type desired and are not intended to restrict selection to fixtures of any particular manufacturer. Fixtures of similar designs and equivalent energy efficiency, light distribution and brightness characteristics, and of equal finish and quality will be acceptable if approved.

3.14.2.1 Accessories

Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation.

3.14.2.2 Ceiling Fixtures

Ceiling fixtures shall be coordinated with and suitable for installation in, on or from the ceiling as shown. Installation and support of fixtures shall be in accordance with NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling, in conformance with UL Elec Const Dir. Surface-mounted fixtures shall be suitable for fastening to the ceiling panel structural supports.

3.14.2.3 Fixtures for Installation in Grid Type Ceilings

Fixtures for installation in grid type ceilings which are smaller than a full tile shall be centered in the tile. 1 by 4 foot (305 by 1219 mm) fixtures shall be mounted along the grid rail as shown. Work above the ceiling shall be coordinated among the trades to provide the lighting layout shown. Fixtures mounted to the grid shall have trim exactly compatible with the grid. Contractor shall coordinate trims with ceiling trades prior to ordering fixtures. Metric fixtures shall be designed to fit the metric grid specified. Fixtures in continuous rows shall be coordinated between trades prior to ordering. Fixtures shall be mounted using independent supports capable of supporting the entire weight of the fixture. No fixture shall rest solely on the ceiling grid. Recessed fixtures installed in seismic areas should be installed utilizing specially designed seismic clips. Junction boxes shall be supported at four points.

3.14.2.4 Suspended Fixtures

Suspended fixtures shall be provided with swivel hangers or hand-strights so that they hang plumb. Pendants, rods, or chains 4 feet (1.2 meters) or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degrees of separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and

gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 10 feet (3.1 meters) or as recommended by the manufacturer, whichever is less.

Suspended fixtures installed in seismic areas shall have 45% swivel hangers and shall be located with no obstructions within the 45% range in all directions. The stem, canopy and fixture shall be capable of 45% swing.

3.14.3 Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp as designated by the manufacturer.

3.15 BATTERY CHARGERS

Battery chargers shall be installed in conformance with NFPA 70.

3.16 EQUIPMENT CONNECTIONS

Wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits 6 feet (2 m) or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

3.16.1 Motors and Motor Control

Motors, motor controls, and motor control centers shall be installed in accordance with NFPA 70, the manufacturer's recommendations, and as indicated. Wiring shall be extended to motors, motor controls, and motor control centers and terminated.

3.16.2 Installation of Government-Furnished Equipment

Wiring shall be extended to the equipment and terminated.

3.16.3 Food Service Equipment Provided Under Other Sections

Wiring shall be extended to the equipment and terminated.

3.17 CIRCUIT PROTECTIVE DEVICES

The Contractor shall calibrate, adjust, set and test each new adjustable circuit protective device to ensure that they will function properly prior to the initial energization of the new power system under actual operating conditions.

3.18 POWER CONDITIONERS

Factory start-up, preventive maintenance, and full service for the specified system shall be available and included upon request. The manufacturer shall directly employ a nationwide service organization of factory-trained field service personnel dedicated to the start-up, maintenance, and repair of the manufacturer's power equipment. The manufacturer shall maintain a national dispatch center 24 hours per day, 365 days per year, to minimize service response time and to maximize availability of qualified service personnel.

3.19 PAINTING AND FINISHING

Field-applied paint on exposed surfaces shall be provided under Section 09900 PAINTS AND COATINGS.

3.20 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Government.

3.21 FIELD TESTING

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 20 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests and develop a comprehensive field test plan. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.21.1 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.21.2 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

- a. Single rod electrode - 25 ohms.
- b. Grid electrode system - 5 ohms.

3.21.3 Ground-Grid Connection Inspection

All below-grade ground-grid connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 24 hours before the site is ready for inspection.

3.21.4 Cable Tests

The Contractor shall be responsible for identifying all equipment and devices that could be damaged by application of the test voltage and ensuring that they have been properly disconnected prior to performing insulation resistance testing. An insulation resistance test shall be performed on all low and medium voltage cables after the cables are installed in their final configuration and prior to energization. The test voltage shall be 500 volts DC applied for one minute between each conductor and ground and between all possible combinations of conductors. The minimum value of resistance shall be:

$R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 1000 / (\text{length of cable in feet})$

Each cable failing this test shall be repaired or replaced. The repaired cable system shall then be retested until failures have been eliminated.

3.21.4.1 Medium Voltage Cable Tests

- a. Continuity test.
- b. Insulation resistance test.
- c. DC high-potential test.

3.21.4.2 Low Voltage Cable Tests

- a. Continuity test.
- b. Insulation resistance test.

3.21.5 Metal Enclosed Busway Tests

- a. Insulation Resistance phase-to-phase, all combinations.
- b. Insulation resistance phase-to-ground, each phase.
- c. AC or DC high-potential test.
- d. Phase rotation test.

3.21.6 Motor Tests

- a. Phase rotation test to ensure proper directions.
- b. Operation and sequence of reduced voltage starters.

- c. High potential test on each winding to ground.
- d. Insulation resistance of each winding to ground.
- e. Vibration test.
- f. Dielectric absorption test on motor.

3.21.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on all liquid-filled transformers 1000 kVA and above

- a. Insulation resistance test phase-to-ground, each phase.
- b. Turns ratio test.
- c. Correct phase sequence.
- d. Correct operation of tap changer.

3.21.8 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers 500 kVA and above.

- a. Insulation resistance test phase-to-ground, each phase.
- b. Turns ratio test.

3.21.9 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers.

3.21.9.1 Circuit Breaker Tests, Medium Voltage

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance tests phase-to-ground, each phase.
- c. Closed breaker contact resistance test.
- d. Power factor test.
- e. High-potential test.
- f. Manual and electrical operation of the breaker.

3.21.9.2 Circuit Breakers, Low Voltage

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance test phase-to-ground, each phase.
- c. Closed breaker contact resistance test.

- d. Manual and electrical operation of the breaker.

3.21.9.3 Circuit Breakers, Molded Case

- a. Insulation resistance test phase-to-phase, all combinations.
- b. Insulation resistance test phase-to-ground, each phase.
- c. Closed breaker contact resistance test.
- d. Manual operation of the breaker.

3.21.10 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. These tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to insure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.22 OPERATING TESTS

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph FIELD TEST REPORTS.

3.23 FIELD SERVICE

3.23.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A VHS format video tape of the entire training shall be submitted.

3.23.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of equipment, assist in the performance of the onsite tests, oversee initial operations, and instruct personnel as to the operational and maintenance features of the equipment.

3.24 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

3.25 FIXTURE DETAILS

Fixture details applicable to this project are attached at the end of this Section.

End of Section

This page intentionally blank